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THE CENTER FOR VOCATIONAL EDUCATION

TEACHING AND LEARNING THE METRIC SYSTEM

This metric instructional package was designed to meet job-related metric measurement needs of students. To use this package students should already know the occupational terminology, measurement terms, and tools currently in use. These materials were prepared with the help of experienced vocational teachers, reviewed by experts, tested in classrooms in different parts of the United States, and revised before distribution.

Each of the five units of instruction contains performance objectives, learning activities, and supporting information in the form of text, exercises, and tables. In addition, suggested teaching techniques are included. At the back of this package are objective-based evaluation items, a page of answers to the exercises and tests, a list of metric materials needed for the activities, references, and a list of suppliers.

Classroom experiences with this instructional package suggest the following teaching-learning strategies:

1. Let the first experiences be informal to make learning the metric system fun.
2. Students learn better when metric units are compared to familiar objects. Everyone should learn to "think metric." Comparing metric units to customary units can be confusing.
3. Students will learn quickly to estimate and measure in metric units by "doing."
4. Students should have experience with measuring activities before getting too much information.
5. Move through the units in an order which emphasizes the simplicity of the metric system (e.g., length to area to volume).
6. Teach one concept at a time to avoid overwhelming students with too much material.

Unit 1 is a general introduction to the metric system of measurement which provides informal, hands-on experiences for the students. This unit enables students to become familiar with the basic metric units, their symbols, and measurement instruments; and to develop a set of mental references for metric values. The metric system of notation also is explained.

Unit 2 provides the metric terms which are used in this occupation and gives experience with occupational measurement tasks.

Unit 3 focuses on job-related metric equivalents and their relationships.

Unit 4 provides experience with recognizing and using metric instruments and tools in occupational measurement tasks. It also provides experience in comparing metric and customary measurement instruments.

Unit 5 is designed to give students practice in converting customary and metric measurements. Students should learn to "think metric" and avoid comparing customary and metric units. However, skill with conversion tables will be useful during the transition to metric in each occupation.

Using These Instructional Materials

This package was designed to help students learn a core of knowledge about the metric system which they will use on the job. The exercises facilitate experiences with measurement instruments, tools, and devices used in this occupation and job-related tasks of estimating and measuring.

This instructional package also was designed to accommodate a variety of individual teaching and learning styles. Teachers are encouraged to adapt these materials to their own classes. For example, the information sheets may be given to students for self-study. References may be used as supplemental resources. Exercises may be used in independent study, small groups, or whole-class activities. All of the materials can be expanded by the teacher.

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Joel H. Magisos
Editors

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UNIT 1

SUGGESTED TEACHING SEQUENCE

1. These introductory exercises may require two or three teaching periods for all five areas of measurement.
2. Exercises should be followed in the order given to best show the relationship between length, area, and volume.
3. Assemble the metric measuring devices (rules, tapes, scales, thermometers, and measuring containers) and objects to be measured.*
4. Set up the equipment at work stations for use by the whole class or as individualized resource activities.
5. Have the students estimate, measure, and record using Exercises 1 through 5.
6. Present information on notation and make Table 1 available.
7. Follow up with group discussion of activities.

*Other school departments may have devices which can be used. Metric suppliers are listed in the reference section.

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OBJECTIVES

The student will demonstrate these skills for the Linear, Area, Volume or Capacity, Mass, and Temperature Exercises, using the metric terms and measurement devices listed here.

SKILLS	EXERCISES				
	Linear (pp. 3 - 4)	Area (pp. 5 - 6)	Volume or Capacity (pp. 7 - 8)	Mass (pp. 9 - 10)	Temperature (p. 11)
1. Recognize and use the unit and its symbol for: 2. Select, use, and read the appropriate measuring instruments for: 3. State or show a physical reference for:	millimetre (mm) centimetre (cm) metre (m)	square centimetre (cm^2) square metre (m^2)	cubic centimetre (cm^3) cubic metre (m^3) litre (l) millilitre (ml)	gram (g) kilogram (kg)	degree Celsius (°C)
4. Estimate within 25% of the actual measure	height, width, or length of objects	the area of a given surface	capacity of containers	the mass of objects in grams and kilograms	the temperature of the air or a liquid
5. Read correctly	metre stick, metric tape measure, and metric rulers		measurements on graduated volume measuring devices	a kilogram scale and a gram scale	A Celsius thermometer

RULES OF NOTATION

1. Symbols are not capitalized unless the unit is a proper name (mm *not* MM).
2. Symbols are not followed by periods (m *not* m.).
3. Symbols are not followed by an *s* for plurals (25 g *not* 25 gs).
4. A space separates the numerals from the unit symbols (4 l *not* 4l).
5. Spaces, not commas, are used to separate large numbers into groups of three digits (45 271 km *not* 45,271 km).
6. A zero precedes the decimal point if the number is less than one (0.52 g *not* .52 g).
7. Litre and metre can be spelled either with an -re or -er ending.

METRIC UNITS, SYMBOLS, AND REFERENTS

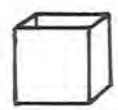
Quantity	Metric Unit	Symbol	Useful Referents
Length	millimetre	mm	Thickness of dime or paper clip wire
	centimetre	cm	Width of paper clip
	metre	m	Height of door about 2 m
	kilometre	km	12-minute walking distance
Area	square centimetre	cm^2	Area of this space 
	square metre	m^2	Area of card table top
	hectare	ha	Football field including sidelines and end zones
Volume and Capacity	millilitre	ml	Teaspoon is 5 ml
	litre	l	A little more than 1 quart
	cubic centimetre	cm^3	Volume of this container 
	cubic metre	m^3	A little more than a cubic yard
Mass	milligram	mg	Apple seed about 10 mg, grain of salt, 1 mg
	gram	g	Nickel about 5 g
	kilogram	kg	Webster's Collegiate Dictionary
	metric ton (1 000 kilograms)	t	Volkswagen Beetle

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Table 1–a

METRIC PREFIXES

Multiples and Submultiples	Prefixes	Symbols
$1\ 000\ 000 = 10^6$	mega (mĕg′ȧ)	M
$1\ 000 = 10^3$	kilo (kĭl′ō)	k
$100 = 10^2$	hecto (hĕk′tō)	h
$10 = 10^1$	deka (dĕk′ȧ)	da
Base Unit $1 = 10^0$		
$0.1 = 10^{-1}$	deci (dĕs′ĭ)	d
$0.01 = 10^{-2}$	centi (sĕn′tĭ)	c
$0.001 = 10^{-3}$	milli (mĭl′ĭ)	m
$0.000\ 001 = 10^{-6}$	micro (mī′krō)	μ

Table 1–b

LINEAR MEASUREMENT ACTIVITIES

Metre, Centimetre, Millimetre

I. THE METRE (m)

A. DEVELOP A FEELING FOR THE SIZE OF A METRE

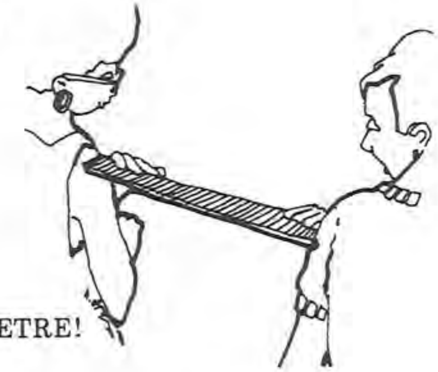
1. Pick up one of the metre sticks and stand it up on the floor. Hold it in place with one hand. Walk around the stick. Now stand next to the stick. With your other hand, touch yourself where the top of the metre stick comes on you.

THAT IS HOW HIGH A METRE IS!

2. Hold one arm out straight at shoulder height. Put the metre stick along this arm until the end hits the end of your fingers. Where is the other end of the metre stick? Touch yourself at that end.

THAT IS HOW LONG A METRE IS!

3. Choose a partner to stand at your side. Move apart so that you can put one end of a metre stick on your partner's shoulder and the other end on your shoulder. Look at the space between you.



THAT IS THE WIDTH OF A METRE!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN METRES

Now you will improve your ability to estimate in metres. Remember where the length and height of a metre was on your body.

For each of the following items:

Estimate the size of the items and write your estimate in the ESTIMATE column. Measure the size with your metre stick and write the answer in the MEASUREMENT column.

Decide how close your estimate was to the actual measure. If your estimate was within 25% of the actual measure you are a "Metric Marvel."

	Estimate (m)	Measurement (m)	How Close Were You?
1. Height of door knob from floor.	______	______	______
2. Height of door.	______	______	______
3. Length of table.	______	______	______
4. Width of table.	______	______	______
5. Length of wall of this room.	______	______	______
6. Distance from you to wall.	______	______	______

Exercise 1

(continued on next page)

II. THE CENTIMETRE (cm)

There are 100 centimetres in one metre. If there are 4 metres and 3 centimetres, you write 403 cm [(4 x 100 cm) + 3 cm = 400 cm + 3 cm].

A. DEVELOP A FEELING FOR THE SIZE OF A CENTIMETRE

1. Hold the metric ruler against the width of your thumbnail. How wide is it? ________ cm
2. Measure your thumb from the first joint to the end. ________ cm
3. Use the metric ruler to find the width of your palm. ________ cm
4. Measure your index or pointing finger. How long is it? ________ cm
5. Measure your wrist with a tape measure. What is the distance around it? ________ cm
6. Use the tape measure to find your waist size. ________ cm

B. DEVELOP YOUR ABILITY TO ESTIMATE IN CENTIMETRES

You are now ready to estimate in centimetres. For each of the following items, follow the procedures used for estimating in metres.

	Estimate (cm)	Measurement (cm)	How Close Were You?
1. Length of a paper clip.	________	________	________
2. Diameter (width) of a coin.	________	________	________
3. Width of a postage stamp.	________	________	________
4. Length of a pencil.	________	________	________
5. Width of a sheet of paper.	________	________	________

III. THE MILLIMETRE (mm)

There are 10 millimetres in one centimetre. When a measurement is 2 centimetres and 5 millimetres, you write 25 mm [(2 x 10 mm) + 5 mm = 20 mm + 5 mm]. There are 1 000 mm in 1 m.

A. DEVELOP A FEELING FOR THE SIZE OF A MILLIMETRE

Using a ruler marked in millimetres, measure:

1. Thickness of a paper clip wire. ________ mm
2. Thickness of your fingernail. ________ mm
3. Width of your fingernail. ________ mm
4. Diameter (width)of a coin. ________ mm
5. Diameter (thickness) of your pencil. ________ mm
6. Width of a postage stamp. ________ mm

B. DEVELOP YOUR ABILITY TO ESTIMATE IN MILLIMETRES

You are now ready to estimate in millimetres. For each of the following items, follow the procedures used for estimating in metres.

	Estimate (mm)	Measurement (mm)	How Close Were You?
1. Thickness of a nickel.	________	________	________
2. Diameter (thickness) of a bolt.	________	________	________
3. Length of a bolt.	________	________	________
4. Width of a sheet of paper.	________	________	________
5. Thickness of a board or desk top.	________	________	________
6. Thickness of a button.	________	________	________

AREA MEASUREMENT ACTIVITIES

Square Centimetre, Square Metre

WHEN YOU DESCRIBE THE AREA OF SOMETHING, YOU ARE SAYING HOW MANY SQUARES OF A GIVEN SIZE IT TAKES TO COVER THE SURFACE.

I. THE SQUARE CENTIMETRE (cm^2)

A. DEVELOP A FEELING FOR A SQUARE CENTIMETRE

1. Take a clear plastic grid, or use the grid on page 6.
2. Measure the length and width of one of these small squares with a centimetre ruler.

   THAT IS ONE SQUARE CENTIMETRE!

3. Place your fingernail over the grid. About how many squares does it take to cover your fingernail? _______cm^2
4. Place a coin over the grid. About how many squares does it take to cover the coin? _______cm^2
5. Place a postage stamp over the grid. About how many squares does it take to cover the postage stamp? _______cm^2
6. Place an envelope over the grid. About how many squares does it take to cover the envelope? _______cm^2
7. Measure the length and width of the envelope in centimetres. Length _______ cm; width _______ cm. Multiply to find the area in square centimetres. _______ cm x _______ cm = _______ cm^2. How close are the answers you have in 6. and in 7.?

B. DEVELOP YOUR ABILITY TO ESTIMATE IN SQUARE CENTIMETRES

You are now ready to develop your ability to estimate in square centimetres.

Remember the size of a square centimetre. For each of the following items, follow the procedures used for estimating in metres.

	Estimate (cm^2)	Measurement (cm^2)	How Close Were You?
1. Index card.	_______	_______	_______
2. Book cover.	_______	_______	_______
3. Photograph.	_______	_______	_______
4. Window pane or desk top.	_______	_______	_______

II. THE SQUARE METRE (m^2)

A. DEVELOP A FEELING FOR A SQUARE METRE

1. Tape four metre sticks together to make a square which is one metre long and one metre wide.
2. Hold the square up with one side on the floor to see how big it is.
3. Place the square on the floor in a corner. Step back and look. See how much floor space it covers.
4. Place the square over a table top or desk to see how much space it covers.
5. Place the square against the bottom of a door. See how much of the door it covers. How many squares would it take to cover the door? _______m^2

   THIS IS HOW BIG A SQUARE METRE IS!

Exercise 2

(continued on next page)

B. DEVELOP YOUR ABILITY TO ESTIMATE IN SQUARE METRES

You are now ready to estimate in square metres. Follow the procedures used for estimating in metres.

	Estimate (m^2)	Measurement (m^2)	How Close Were You?
1. Door.	______	______	______
2. Full sheet of newspaper.	______	______	______
3. Chalkboard or bulletin board.	______	______	______
4. Floor.	______	______	______
5. Wall.	______	______	______
6. Wall chart or poster.	______	______	______
7. Side of file cabinet.	______	______	______

CENTIMETRE GRID

VOLUME MEASUREMENT ACTIVITIES

Cubic Centimetre, Litre, Millilitre, Cubic Metre

I. THE CUBIC CENTIMETRE (cm^3)

A. DEVELOP A FEELING FOR THE CUBIC CENTIMETRE

1. Pick up a colored plastic cube. Measure its length, height, and width in centimetres.

   THAT IS ONE CUBIC CENTIMETRE!

2. Find the volume of a plastic litre box.

   a. Place a ROW of cubes against the bottom of one side of the box. How many cubes fit in the row?________

   b. Place another ROW of cubes against an adjoining side of the box. How many rows fit inside the box to make one layer of cubes? ________

   How many cubes in each row?________

   How many cubes in the layer in the bottom of the box?________

   c. Stand a ROW of cubes up against the side of the box. How many LAYERS would fit in the box? ________

   How many cubes in each layer? ________

   How many cubes fit in the box altogether?________

   THE VOLUME OF THE BOX IS ________CUBIC CENTIMETRES.

   d. Measure the length, width, and height of the box in centimetres. Length ________cm; width ________cm; height ________cm. Multiply these numbers to find the volume in cubic centimetres.

   ______cm x ______cm x ______cm = ______cm^3.
   Are the answers the same in c. and d.?

B. DEVELOP YOUR ABILITY TO ESTIMATE IN CUBIC CENTIMETRES

You are now ready to develop your ability to estimate in cubic centimetres.

Remember the size of a cubic centimetre. For each of the following items, use the procedures for estimating in metres.

	Estimate (cm^3)	Measurement (cm^3)	How Close Were You?
1. Index card file box.	______	______	______
2. Freezer container.	______	______	______
3. Paper clip box.	______	______	______
4. Box of staples.	______	______	______

II. THE LITRE (l)

A. DEVELOP A FEELING FOR A LITRE

1. Take a one litre beaker and fill it with water.
2. Pour the water into paper cups, filling each as full as you usually do. How many cups do you fill?

   THAT IS HOW MUCH IS IN ONE LITRE!
3. Fill the litre container with rice.

   THAT IS HOW MUCH IT TAKES TO FILL A ONE LITRE CONTAINER!

(continued on next page)

B. DEVELOP YOUR ABILITY TO ESTIMATE IN LITRES

You are now ready to develop your ability to estimate in litres. To write two and one-half litres, you write 2.5 l, or 2.5 litres. To write one-half litre, you write 0.5 l, or 0.5 litre. To write two and three-fourths litres, you write 2.75 l, or 2.75 litres.

For each of the following items, use the procedures for estimating in metres.

	Estimate (l)	Measurement (l)	How Close Were You?
1. Medium-size freezer container.	______	_________	_______
2. Large freezer container.	______	_________	_______
3. Small freezer container.	______	_________	_______
4. Bottle or jug.	______	_________	_______

III. THE MILLILITRE (ml)

There are 1 000 millilitres in one litre. 1 000 ml = 1 litre. Half a litre is 500 millilitres, or 0.5 litre = 500 ml.

A. DEVELOP A FEELING FOR A MILLILITRE

1. Examine a centimetre cube. Anything which holds 1 cm^3 holds 1 ml.
2. Fill a 1 millilitre measuring spoon with rice. Empty the spoon into your hand. Carefully pour the rice into a small pile on a sheet of paper.

   THAT IS HOW MUCH ONE MILLILITRE IS!
3. Fill the 5 ml spoon with rice. Pour the rice into another pile on the sheet of paper.

   THAT IS 5 MILLILITRES, OR ONE TEASPOON!
4. Fill the 15 ml spoon with rice. Pour the rice into a third pile on the paper.

   THAT IS 15 MILLILITRES, OR ONE TABLESPOON!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN MILLILITRES

You are now ready to estimate in millilitres. Follow the procedures used for estimating metres.

	Estimate (ml)	Measurement (ml)	How Close Were You?
1. Small juice can.	______	_________	_______
2. Paper cup or tea cup.	______	_________	_______
3. Soft drink can.	______	_________	_______
4. Bottle.	______	_________	_______

IV. THE CUBIC METRE (m^3)

A. DEVELOP A FEELING FOR A CUBIC METRE

1. Place a one metre square on the floor next to the wall.
2. Measure a metre UP the wall.
3. Picture a box that would fit into that space.

   THAT IS THE VOLUME OF ONE CUBIC METRE!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN CUBIC METRES

For each of the following items, follow the estimating procedures used before.

	Estimate (m^3)	Measurement (m^3)	How Close Were You?
1. Office desk.	______	_________	_______
2. File cabinet.	______	_________	_______
3. Small room.	______	_________	_______

MASS (WEIGHT) MEASUREMENT ACTIVITIES

Kilogram, Gram

The mass of an object is a measure of the amount of matter in the object. This amount is always the same unless you add or subtract some matter from the object. Weight is the term that most people use when they mean mass. The weight of an object is affected by gravity; the mass of an object is not. For example, the weight of a person on earth might be 120 pounds; that same person's weight on the moon would be 20 pounds. This difference is because the pull of gravity on the moon is less than the pull of gravity on earth. A person's mass on the earth and on the moon would be the same. The metric system does not measure weight--it measures mass. We will use the term mass here.

The symbol for gram is g.

The symbol for kilogram is kg.

There are 1 000 grams in one kilogram, or 1 000 g = 1 kg.

Half a kilogram can be written as 500 g,or 0.5 kg.

A quarter of a kilogram can be written as 250 g,or 0.25 kg.

Two and three-fourths kilograms is written as 2.75 kg.

I. THE KILOGRAM (kg)

DEVELOP A FEELING FOR THE MASS OF A KILOGRAM

Using a balance or scale, find the mass of the items on the table. Before you find the mass, notice how heavy the object "feels" and compare it to the reading on the scale or balance.

		Mass (kg)
1.	1 kilogram box.	______
2.	Textbook.	______
3.	Bag of sugar.	______
4.	Package of paper.	______
5.	Your own mass.	______

B. DEVELOP YOUR ABILITY TO ESTIMATE IN KILOGRAMS

For the following items ESTIMATE the mass of the object in kilograms, then use the scale or balance to find the exact mass of the object. Write the exact mass in the MEASUREMENT column. Determine how close your estimate is:

		Estimate (kg)	Measurement (kg)	How Close Were You?
1.	Bag of rice.	______	______	______
2.	Bag of nails.	______	______	______
3.	Large purse or briefcase.	______	______	______
4.	Another person.	______	______	______
5.	A few books.	______	______	______

(continued on next page)

II. THE GRAM (g)

A. DEVELOP A FEELING FOR A GRAM

1. Take a colored plastic cube. Hold it in your hand. Shake the cube in your palm as if shaking dice. Feel the pressure on your hand when the cube is in motion, then when it is not in motion.

   THAT IS HOW HEAVY A GRAM IS!

2. Take a second cube and attach it to the first. Shake the cubes in first one hand and then the other hand; rest the cubes near the tips of your fingers, moving your hand up and down.

   THAT IS THE MASS OF TWO GRAMS!

3. Take five cubes in one hand and shake them around.

   THAT IS THE MASS OF FIVE GRAMS!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN GRAMS

You are now ready to improve your ability to estimate in grams. Remember how heavy the 1 gram cube is, how heavy the two gram cubes are, and how heavy the five gram cubes are. For each of the following items, follow the procedures used for estimating in kilograms.

	Estimate (g)	Measurement (g)	How Close Were You?
1. Two thumbtacks.	______	______	______
2. Pencil.	______	______	______
3. Two-page letter and envelope.	______	______	______
4. Nickel.	______	______	______
5. Apple.	______	______	______
6. Package of margarine.	______	______	______

TEMPERATURE MEASUREMENT ACTIVITIES

Degree Celsius

I. DEGREE CELSIUS (°C)

Degree Celsius (°C) is the metric measure for temperature.

A. DEVELOP A FEELING FOR DEGREE CELSIUS

Take a Celsius thermometer. Look at the marks on it.

1. Find 0 degrees.

   WATER FREEZES AT ZERO DEGREES CELSIUS (0°C)

   WATER BOILS AT 100 DEGREES CELSIUS (100°C)

2. Find the temperature of the room. ______°C. Is the room cool, warm, or about right?

3. Put some hot water from the faucet into a container. Find the temperature. ______ °C. Dip your finger quickly in and out of the water. Is the water very hot, hot, or just warm?

4. Put some cold water in a container with a thermometer. Find the temperature. ______ °C. Dip your finger into the water. Is it cool, cold, or very cold?

5. Bend your arm with the inside of your elbow around the bottom of the thermometer. After about three minutes find the temperature. ______ °C. Your skin temperature is not as high as your body temperature.

   NORMAL BODY TEMPERATURE IS 37 DEGREES CELSIUS (37°C).

   A FEVER IS 39°C.

   A VERY HIGH FEVER IS 40°C.

B. DEVELOP YOUR ABILITY TO ESTIMATE IN DEGREES CELSIUS

For each item, ESTIMATE and write down how many degrees Celsius you think it is. Then measure and write the MEASUREMENT. See how close your estimates and actual measurements are.

	Estimate (°C)	Measurement (°C)	How Close Were You?
1. Mix some hot and cold water in a container. Dip your finger into the water.	______	______	______
2. Pour out some of the water. Add some hot water. Dip your finger quickly into the water.	______	______	______
3. Outdoor temperature.	______	______	______
4. Sunny window sill.	______	______	______
5. Mix of ice and water.	______	______	______
6. Temperature at floor.	______	______	______
7. Temperature at ceiling.	______	______	______

UNIT 2

OBJECTIVES

The student will recognize and use the metric terms, units, and symbols used in this occupation.

- Given a metric unit, state its use in this occupation.
- Given a measurement task in this occupation, select the appropriate metric unit and measurement tool.

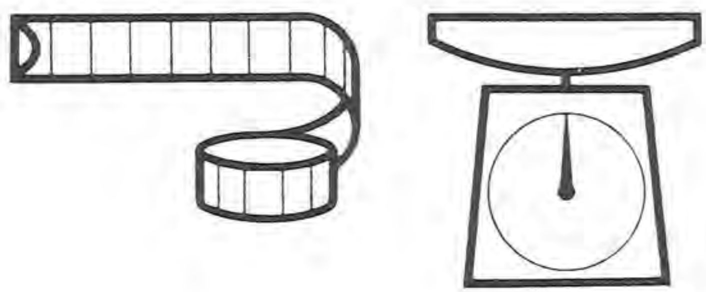
SUGGESTED TEACHING SEQUENCE

1. Assemble metric measurement tools (rules, tapes, scales, thermometers, etc.) and objects related to this occupation.
2. Discuss with students how to read the tools.
3. Present and have students discuss Information Sheet 2 and Table 2.
4. Have students learn occupationally-related metric measurements by completing Exercise 6 and the appropriate Exercise 7.
5. Test performance by using Section A of "Testing Metric Abilities."

METRICS IN THIS OCCUPATION

Changeover to the metric system is under way. Large corporations are already using metric measurement to compete in the world market. The metric system has been used in various parts of industrial and scientific communities for years. Legislation, passed in 1975, authorizes an orderly transition to use of the metric system. As businesses and industries make this metric changeover, employees will need to use metric measurement in job-related tasks.

Table 2 lists those metric terms which are most commonly used in this occupation. These terms are replacing the measurement units used currently. What kinds of job-related tasks use measurement? Think of the many different kinds of measurements you now make and use Table 2 to discuss the metric terms which replace them. See if you can add to the list of uses beside each metric term.



METRIC UNITS FOR COPY PREPARATION, LAYOUT AND DESIGN, TYPE COMPOSITION

Quantity	Unit	Symbol	Use
Length	millimetre	mm	Film, plates, blanket, press size, paper, margins, line length, ribbons, headlining, type size
	centimetre	cm	Sheet film,* print paper, layout, masking sheet* type size, Rubylith, acetate
Mass	gram	g	Ink, dry powders and concentrates, pliable adhesive
	kilogram	kg	Mass (weight) of equipment, quantity purchase of supplies, shipping
Volume/Capacity	millilitre	ml	Sprays, India ink, water, alcohol, rubber cement, wax, paints
	litre	l	Developing, fixing, hypo solutions; bulk ink; developing tanks and trays**
	cubic centimetre	cm^3	Developing tanks and trays**
Pressure	kilopascal	kPa	Air pressure and vacuum settings
Temperature	degree Celsius	°C	Room temperature, solution temperature, adhesive wax coating machine temperature, dry mount press temperature
Dilutions/Concentrates	millilitres per litre	ml/l	Diluting rubber cement, mixing solutions
	grams per litre	g/l	Mixing dry powders or crystals to liquids
Application rates	millilitres per square metre	ml/m^2	Estimating materials needed and applying materials
	grams per square metre	g/m^2	

*Either centimetres or millimetres may be used. A final decision has not been made by U.S. manufacturers. To obtain current information, contact the National Association of Photographic Manufacturers.

**Capacities of tanks, trays, and reservoirs can be given either in terms of liquid capacity (millilitres and litres) or in terms of cubic volume (cubic centimetres) of the inside space.

Table 2

TRYING OUT METRIC UNITS

To give you practice with metric units, first estimate the measurements of the items below. Write down your best guess next to the item. Then actually measure the item and write down your answers using the correct metric symbols. The more you practice, the easier it will be.

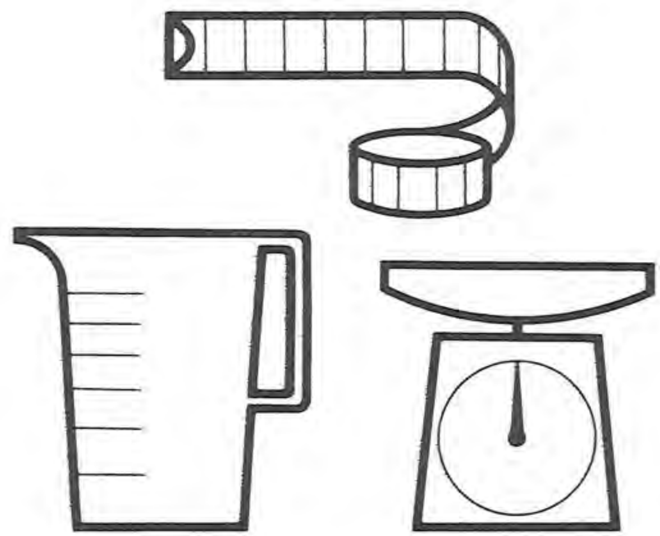
	Estimate	Actual
Length		
1. Palm width		
2. Hand span		
3. Your height		
4. Face of large type		
5. Spacing between lines of type		
6. Height of drawing table		
7. Speedball pen point width		
8. Dia. of proportional scale		
9. Length of "T" square		
Area		
10. Sheet of paper		
11. Drawing board top		
12. Floor space for composing room		
13. Sheet of mounting board		
14. A photo		
Volume/Capacity		
15. Small bottle		

	Estimate	Actual
16. Measuring cup (metric)		
17. India ink bottle		
18. Rubber cement container		
19. Jar of tempra color		
20. Dross drum		
21. Small box or package		
22. Safety can		
Mass		
23. Ream of paper		
24. Nickel		
25. Yourself		
26. Block of wax		
27. A litre of water (net)		
28. A quantity of tracing paper		
Temperature		
29. Room temperature		
30. Outside temperature		
31. Hot tap water		
32. Cold tap water		

COPY PREPARATION WITH METRICS

It is important to know what metric measurement to use. Show what measurement to use in the following situations.

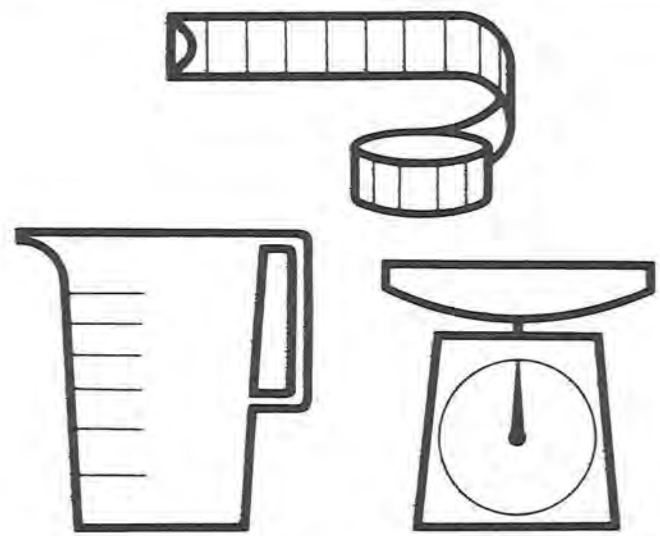
1. Dimensions of drawing table	
2. Width of trim or bleed area	
3. Dimensions of a clip-out or adhesive image	
4. Quantity of developing solution	
5. Quantity of drawing fluid	
6. Length of a roll of transparent tape	
7. Width of pressure sensitive chart tapes	
8. Temperature of refrigerated storage area	
9. Width of gripper margins	
10. Volume of developer for filling photo-type printer	
11. Developer solution for process camera	
12. Mixing rate to prepare developer solutions from powdered chemicals	
13. Ordering dry powder for electro-static image carrier processor	
14. Diluting rubber cement	
15. Length of roll of paper	
16. Dimensions of illustration board	
17. Height and width of adhesive letters	
18. Quantity of press ink	
19. India ink or drawing fluids	
20. Ordering rubber bands	
21. Air pressure settings on equipment	



LAYOUT WITH METRICS

It is important to know what metric measurement to use. Show what measurement to use in the following situations.

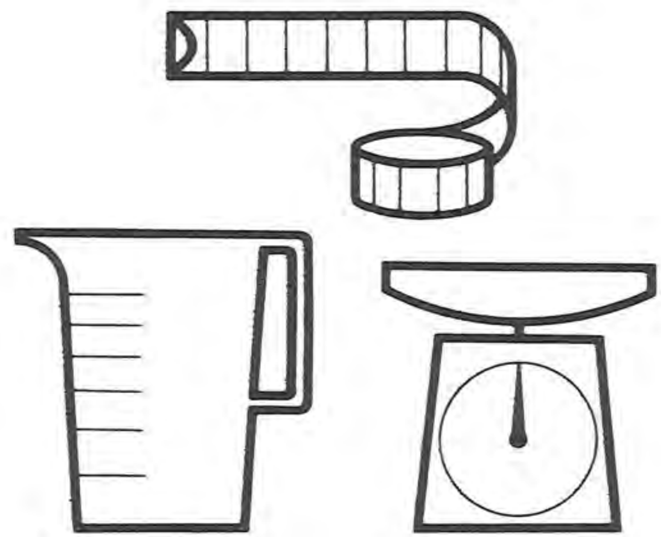
1. Length of paper cutter bar	
2. Dimensions of acetate sheet	
3. Height of transfer letters	
4. Application rate for acrylic paints	
5. Width of margins on magazine or poster layout	
6. Width of trim or bleed area	
7. Dimensions of large size poster board	
8. Volume of solution in developing tray	
9. Mass of a quantity of cotton	
10. Mass of a box of rubber bands	
11. Volume of liquid in a liquid soap container	
12. Dimensions of a photograph	
13. Width of lithograph tape or other tape	
14. Dimensions of a section of copy in a comprehensive layout	
15. Dimensions of largest letters in a layout	
16. Dimensions of one piece of artwork on a layout	
17. Capacity of developing tanks and trays	
18. Volume of liquid in a can of spray	
19. Quantity of ink	
20. Application rate of ink	
21. Dilution of liquid developer concentrate for photo-type printer	
22. Dilution rate for powdered fixer	



COMPOSITION WITH METRICS

It is important to know what metric measurement to use. Show what measurement to use in the following situations.

1. Length of master	
2. Width of master	
3. Mass of a can of spray	
4. Mass of an image carrier	
5. Mass of a box of presensitized carriers	
6. Volume of a camera/processor tank	
7. Length of copyboard	
8. Width of rubber blanket	
9. Application rate of press ink	
10. Application rate of liquid developer	
11. Thickness of paper	
12. Thickness of emulsion on image master	
13. Mass of lithographic stone	
14. Temperature of photographic processing solutions	
15. Temperature of refrigerated storage area	
16. Mass of a Ludlow press	
17. Margin width	
18. Gripper width	
19. Capacity of phototype printer tanks	
20. Pressure or vacuum settings	
21. Dilution rate for mixing liquid developer and water	
22. Dilution rate for mixing fixer crystals and water	



UNIT 3

OBJECTIVE

The student will recognize and use metric equivalents.

- Given a metric unit, state an equivalent in a larger or smaller metric unit.

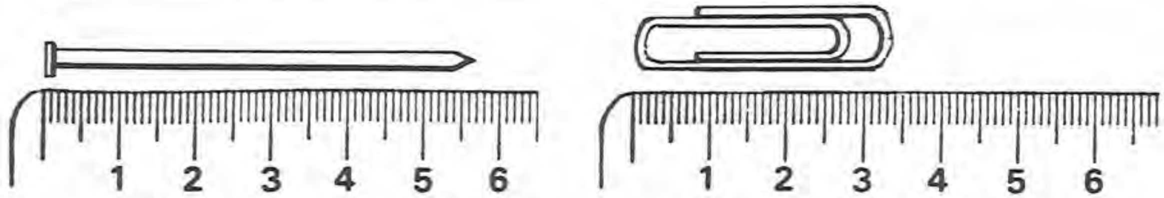
SUGGESTED TEACHING SEQUENCE

1. Make available the Information Sheets (3 - 8) and the associated Exercises (8 - 14), one at a time.
2. As soon as you have presented the Information, have the students complete each Exercise.
3. Check their answers on the page titled ANSWERS TO EXERCISES AND TEST.
4. Test performance by using Section B of "Testing Metric Abilities."

THE CENTER FOR VOCATIONAL EDUCATION

METRIC-METRIC EQUIVALENTS

Centimetres and Millimetres



Look at the picture of the nail next to the ruler. The nail is 57 mm long. This is 5 cm + 7 mm. There are 10 mm in each cm, so 1 mm = 0.1 cm (one-tenth of a centimetre). This means that 7 mm = 0.7 cm, so 57 mm = 5 cm + 7 mm
= 5 cm + 0.7 cm
= 5.7 cm. Therefore 57 mm is the same as 5.7 cm.

Now measure the paper clip. It is 34 mm. This is the same as 3 cm + ________ mm. Since each millimetre is 0.1 cm (one-tenth of a centimetre), 4 mm = ________ cm. So, the paper clip is 34 mm = 3 cm + 4 mm
= 3 cm + 0.4 cm
= 3.4 cm. This means that 34 mm is the same as 3.4 cm.

Information Sheet 3

Now you try some.

a) 26 mm = ________ cm
b) 583 mm = ________ cm
c) 94 mm = ________ cm
d) 680 mm = ________ cm
e) 132 mm = ________ cm
f) 802 mm = ________ cm
g) 1 400 mm = ________ cm
h) 2 307 mm = ________ cm

Exercise 8

Metres, Centimetres, and Millimetres

There are 100 centimetres in one metre. Thus,

$$2 \text{ m} = 2 \times 100 \text{ cm} = 200 \text{ cm},$$
$$3 \text{ m} = 3 \times 100 \text{ cm} = 300 \text{ cm},$$
$$8 \text{ m} = 8 \times 100 \text{ cm} = 800 \text{ cm},$$
$$36 \text{ m} = 36 \times 100 \text{ cm} = 3\ 600 \text{ cm}.$$

There are 1 000 millimetres in one metre, so

$$2 \text{ m} = 2 \times 1\ 000 \text{ mm} = 2\ 000 \text{ mm},$$
$$3 \text{ m} = 3 \times 1\ 000 \text{ mm} = 3\ 000 \text{ mm},$$
$$6 \text{ m} = 6 \times 1\ 000 \text{ mm} = 6\ 000 \text{ mm},$$
$$24 \text{ m} = 24 \times 1\ 000 \text{ mm} = 24\ 000 \text{ mm}.$$

From your work with decimals you should know that

one-half of a metre can be written 0.5 m (five-tenths of a metre),
one-fourth of a centimetre can be written 0.25 cm
(twenty-five hundredths of a centimetre).

This means that if you want to change three-fourths of a metre to millimetres, you would multiply by 1 000. So

$$0.75 \text{ m} = 0.75 \times 1\ 000 \text{ mm}$$
$$= \frac{75}{100} \times 1\ 000 \text{ mm}$$
$$= 75 \times \frac{1\ 000}{100} \text{ mm}$$
$$= 75 \times 10 \text{ mm}$$
$$= 750 \text{ mm}.$$ This means that 0.75 m = 750 mm.

Information Sheet 4

Fill in the following chart.

metre m	centimetre cm	millimetre mm
1	100	1 000
2	200	
3		
9		
		5 000
74		
0.8	80	
0.6		600
	2.5	25
		148
	639	

Exercise 9

Millilitres to Litres

There are 1 000 millilitres in one litre. This means that

2 000 millilitres is the same as 2 litres,
3 000 ml is the same as 3 litres,
4 000 ml is the same as 4 litres,
12 000 ml is the same as 12 litres.

Since there are 1 000 millilitres in each litre, one way to change millilitres to litres is to divide by 1 000. For example,

$$1\ 000 \text{ ml} = \frac{1\ 000}{1\ 000} \text{ litre} = 1 \text{ litre}.$$

Or

$$2\ 000 \text{ ml} = \frac{2\ 000}{1\ 000} \text{ litres} = 2 \text{ litres}.$$

And, as a final example,

$$28\ 000 \text{ ml} = \frac{28\ 000}{1\ 000} \text{ litres} = 28 \text{ litres}.$$

What if something holds 500 ml? How many litres is this? This is worked the same way.

$500 \text{ ml} = \frac{500}{1\ 000} \text{ litre} = 0.5$ litre (five-tenths of a litre). So 500 ml is the same as one-half (0.5) of a litre.

Change 57 millilitres to litres.

$57 \text{ ml} = \frac{57}{1\ 000} \text{ litre} = 0.057$ litre (fifty-seven thousandths of a litre).

Information Sheet 5

Now you try some. Complete the following chart.

millilitres (ml)	litres (l)
3 000	3
6 000	
	8
14 000	
	23
300	0.3
700	
	0.9
250	
	0.47
275	

Exercise 10

Litres to Millilitres

What do you do if you need to change litres to millilitres? Remember, there are 1 000 millilitres in one litre, or 1 litre = 1 000 ml.

So,

2 litres = 2 x 1 000 ml = 2 000 ml,
7 litres = 7 x 1 000 ml = 7 000 ml,
13 litres = 13 x 1 000 ml = 13 000 ml,
0.65 litre = 0.65 x 1 000 ml = 650 ml.

Information Sheet 6

Now you try some. Complete the following chart.

litres l	millilitres ml
8	8 000
5	
46	
	32 000
0.4	
0.53	
	480

Exercise 11

Grams to Kilograms

There are 1 000 grams in one kilogram. This means that

2 000 grams is the same as 2 kilograms,

5 000 g is the same as 5 kg,

700 g is the same as 0.7 kg, and so on.

To change from grams to kilograms, you use the same procedure for changing from millilitres to litres.

Information Sheet 7

Try the following ones.

grams g	kilograms kg
4 000	4
9 000	
23 000	
	8
300	
275	

Exercise 12

Kilograms to Grams

To change kilograms to grams, you multiply by 1 000.

4 kg = 4 x 1 000 g = 4 000 g,
23 kg = 23 x 1 000 g = 23 000 g,
0.75 kg = 0.75 x 1 000 g = 750 g.

Information Sheet 8

Complete the following chart.

kilograms kg	grams g
7	7 000
11	
	25 000
0.4	
0.63	
	175

Exercise 13

Changing Units at Work

Some of the things you use in this occupation may be measured in different metric units. Practice changing each of the following to metric equivalents by completing these statements.

a) 500 cm of litho tape is ______________ m
b) 250 ml of solution is ______________ l
c) 30 cm glass stirring rod is ______________ mm
d) 2 500 g of fixer crystals is ______________ kg
e) 120 mm photo is ______________ cm
f) 0.25 litre of rubber cement is ______________ ml
g) 2 cm Speedball pen is ______________ mm
h) 2.5 cm sable brush is ______________ mm
i) 0.5 litre of India ink is ______________ ml
j) 10 m roll of lithographers tape is ______________ cm
k) 50 m roll of cellophane tape is ______________ cm
l) 300 mm of tracing paper is ______________ cm
m) 5 cm letter height is ______________ mm
n) 0.5 cm letter thickness is ______________ mm
o) 900 mm poster board is ______________ cm
p) 24 cm of type copy is ______________ mm
q) 500 g of dry powder is ______________ kg
r) 1 000 kg of type metal is ______________ t

Exercise 14

UNIT 4

OBJECTIVE

The student will recognize and use instruments, tools, and devices for measurement tasks in this occupation.

- Given metric and Customary tools, instruments, or devices, differentiate between metric and Customary.
- Given a measurement task, select and use an appropriate tool, instrument or device.
- Given a metric measurement task, judge the metric quantity within 20% and measure to the accuracy required by the task.

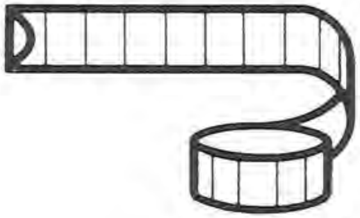
SUGGESTED TEACHING SEQUENCE

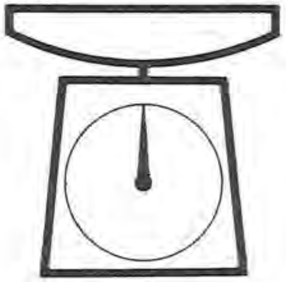
1. Assemble metric and Customary measuring tools and devices (rules, scales, °C thermometer, wrenches, micrometer, vernier calipers, feeler gages) and display in separate groups at learning stations.
2. Have students examine metric tools and instruments for distinguishing characteristics and compare them with Customary tools and instruments.
3. Have students verbally describe characteristics.
4. Present or make available Information Sheet 9.
5. Mix metric and Customary tools or equipment at learning station. Give students appropriate Exercises 15 and 16.
6. Test performance by using Section C of "Testing Metric Abilities."

SELECTING AND USING METRIC INSTRUMENTS , TOOLS AND DEVICES

Selecting an improper tool, misreading a scale, or misinterpreting figures can result in improper forms, damaged materials, or injury to self or fellow workers. For example: The weight markings on a new German-built offset press were read as 2000 lbs. instead of 2 000 kilograms (4400 lbs.). The press was placed on a 1 ton elevator. The elevator slowly sank to the basement instead of lifting the press to the third floor. Much time and money was lost. Here are some suggestions:

1. Find out in advance whether Customary or metric units, tools, instruments, or products are needed for a given task.
2. Examine the tool or instrument before using it.
3. The metric system is a decimal system. Look for units marked off in whole numbers, tens or tenths, hundreds or hundredths.
4. Look for metric symbols on the tools or gages such as m, mm, kg, g, kPa.
5. Look for decimal fractions (0.25) or decimal mixed fractions (2.50) rather than common fractions (3/8).
6. Some products may have a special metric symbol such as a block M to show they are metric.
7. Don't force adjustments, gages, or devices which are not working properly.
8. Practice selecting and using tools, instruments, and devices.





WHICH TOOLS FOR THE JOB?

Practice and prepare to demonstrate your ability to *identify, select, and use* metric-scaled tools and instruments for the tasks given below. You should be able to use the measurement tools to the appropriate precision of the tool, instrument, or task.

1. Determine margins and type area of a page.
2. Compute the type area of 16 pages.
3. Determine the proper layout for a ruled form.
4. Establish page margins and determine number of lines that can be used for type of a given size.
5. Compute the reduction of a photo by a formula and by the diagonal line method.
6. Compute the mass of 1 gal. of rubber cement.
7. Check copy preparation area for correct temperature and relative humidity.
8. Determine the spacing of lines on a ruled form according to customer specifications.
9. Prepare paste-up and indicate trim.
10. Determine the number of lines to be drawn for a business form.
11. Measure the layout area for a computer key punch card.
12. Determine the amount of wax needed to operate a wax coater.
13. Determine the amount of overlay material needed for two color layout.

Exercise 15
(Copy Preparation)

MEASURING UP IN COPY PREPARATION

For the tasks below, estimate the metric measurement within 20% of actual measurement, and verify the estimation by measuring to within 2% of actual measurement.

	Estimate	Verify
1. Measure of a line of type		
2. Glass area of a light table		
3. Work area required for copy preparation		
4. Volume of a partly full bottle of rubber cement		
5. Mass of ream of layout sheets for full-size press sheet		
6. Spacing of columns on ruled form		
7. Paste-up in centimetres: a. Length		
b. Width		
8. Dimensions of piece of illustration board: a. Length		
b. Width		
9. Dimensions of a photo: a. Length		
b. Width		

Exercise 16
(Copy Preparation)

WHICH TOOLS FOR THE JOB?

Practice and prepare to demonstrate your ability to *identify, select, and use* metric-scaled tools and instruments for the tasks given below. You should be able to use the measurement tools to the appropriate precision of the tool, instrument, or task.

1. Determine horizontal and vertical center lines of a sheet of mounting board.
2. Estimate the cost of ten pieces of Ulano Rubylith, 560 mm x 425 mm.
3. Calculate the shipping mass of an amount of rubber cement.
4. Estimate the capacity of a waxer fountain.
5. Space register marks in even thirds of the layout.
6. Find the volume of a carton of wax cakes.
7. Determine the proper layout for a ruled form.
8. Check layout and design area for correct temperature and relative humidity readings.
9. Set compass to draw a circle 180 mm in diameter.
10. Determine the various sizes of type styles available from a headliner.
11. Determine the justification for aligning a right hand margin.
12. Determine proportional spacing for a poster.

Exercise 15
(Layout and Design)

MEASURING UP IN LAYOUT AND DESIGN

For the tasks below, estimate the metric measurement to within 20% of actual measurement, and verify the estimation by measuring to within 2% of actual measurement.

	Estimate	Verify
1. The longest side of a triangle		
2. Surface of the drawing table		
3. A Speedball pen 2 cm wide		
4. A lettering guide for 25 mm letter height		
5. A 50 mm margin on a layout		
6. Dimensions of a photo for a layout		
7. Mass of a package of tracing paper		
8. Capacity of a bottle of drawing ink		
9. Replenish photo-type printer developer		
10. Area required for layout and design operation		
11. Volume of one-year lab supply of rubber cement		
12. Select a 10 mm wide sable brush		
13. Determine the amount of photo-type print developer in a partly filled bottle		

Exercise 16
(Layout and Design)

WHICH TOOLS FOR THE JOB?

Practice and prepare to demonstrate your ability to *identify, select, and use* metric-scaled tools and instruments for the tasks given below. You should be able to use the measurement tools to the appropriate precision of the tool, instrument, or task.

1. Determine mass of type lead in customer order.
2. Check metal crucible for correct temperature.
3. Space type pages for imposition.
4. Find the amount of photoprint paper required for a photocomposition order.
5. Establish margins, line measure and type area for page size.
6. Determine number of type characters per page of predetermined type size and line measure.
7. Estimate the volume of a one-year supply of developer for phototypesetter composer.
8. Determine volume of activator in marked bottle for each batch of solution for photostabilization processor.
9. Find the volume of liquid remaining in a partly filled bottle or jug.
10. Find the application rate for a compound used in composition.
11. Determine the mass of an electric typewriter.
12. Measure the width and length of preprinted artwork for a chart or graph.
13. Measure the temperature of a type composing room.

Exercise 15
(Type Composition)

MEASURING UP IN TYPE COMPOSITION

For the tasks below, estimate the metric measurement to within 20% of actual measurement, and verify the estimation by measuring to the precision of the tool.

	Estimate	Verify
1. Amount of white space on a composed page		
2. Volume of solution needed to fill a phototype printer tank		
3. Area of a drawing board of a light table		
4. Length and width of a headliner strip		
5. Temperature of: a. Room		
b. Outside		
6. Length of composing stick		
7. Capacity of a solvent can		
8. Length and width of a type form		
9. Mass of an electric typewriter		
10. Margin measurements for a two-page 215 mm by 280 mm layout a. Head		
b. Gutter		
c. Inner		
d. Outside		

Exercise 16
(Type Composition)

UNIT 5

OBJECTIVE

The student will recognize and use metric and Customary units interchangeably in ordering, selling, and using products and supplies in this occupation.

- Given a Customary (or metric) measurement, find the metric (or Customary) equivalent on a conversion table.
- Given a Customary unit, state the replacement unit.

SUGGESTED TEACHING SEQUENCE

1. Assemble packages and containers of materials.
2. Present or make available Information Sheet 10 and Table 3.
3. Have students find approximate metric-Customary equivalents by using Exercise 17.
4. Test performance by using Section D of "Testing Metric Abilities."

METRIC-CUSTOMARY EQUIVALENTS

During the transition period there will be a need for finding equivalents between systems. Conversion tables list calculated equivalents between the two systems. When a close equivalent is needed, a conversion table can be used to find it. Follow these steps:

1. Determine which conversion table is needed.
2. Look up the known number in the appropriate column; if not listed, find numbers you can add together to make the total of the known number.
3. Read the equivalent(s) from the next column.

Table 3 on the next page gives an example of a metric-Customary conversion table which you can use for practice in finding approximate equivalents. Table 3 can be used with Exercise 17, Part 2 and Part 3.

Below is a table of metric-Customary equivalents which tells you what the metric replacements for Customary units are.* This table can be used with Exercise 17, Part 1 and Part 3. The symbol ≈ means "nearly equal to."

1 cm ≈ 0.39 inch	1 inch ≈ 2.54 cm	1 ml ≈ 0.2 tsp	1 tsp ≈ 5 ml
1 m ≈ 3.28 feet	1 foot ≈ 0.305 m	1 ml ≈ 0.07 tbsp	1 tbsp ≈ 15 ml
1 m ≈ 1.09 yards	1 yard ≈ 0.91 m	1 l ≈ 33.8 fl oz	1 fl oz ≈ 29.6 ml
1 km ≈ 0.62 mile	1 mile ≈ 1.61 km	1 l ≈ 4.2 cups	1 cup ≈ 237 ml
1 cm^2 ≈ 0.16 sq in	1 sq in ≈ 6.5 cm^2	1 l ≈ 2.1 pts	1 pt ≈ 0.47 l
1 m^2 ≈ 10.8 sq ft	1 sq ft ≈ 0.09 m^2	1 l ≈ 1.06 qt	1 qt ≈ 0.95 l
1 m^2 ≈ 1.2 sq yd	1 sq yd ≈ 0.8 m^2	1 l ≈ 0.26 gal	1 gal ≈ 3.79 l
1 hectare ≈ 2.5 acres	1 acre ≈ 0.4 hectare	1 gram ≈ 0.035 oz	1 oz ≈ 28.3 g
1 cm^3 ≈ 0.06 cu in	1 cu in ≈ 16.4 cm^3	1 kg ≈ 2.2 lb	1 lb ≈ 0.45 kg
1 m^3 ≈ 35.3 cu ft	1 cu ft ≈ 0.03 m^3	1 metric ton ≈ 2205 lb	1 ton ≈ 907.2 kg
1 m^3 ≈ 1.3 cu yd	1 cu yd ≈ 0.8 m^3	1 kPa ≈ 0.145 psi	1 psi ≈ 6.895 kPa

*Adapted from *Let's Measure Metric. A Teacher's Introduction to Metric Measurement.* Division of Educational Redesign and Renewal, Ohio Department of Education, 65 S. Front Street, Columbus, OH 43215, 1975.

CONVERSION TABLES

MILLIMETRES TO INCHES

mm	Inches	mm	Inches	mm	Inches	mm	Inches
100	3.93	10	0.39	1	0.04	0.1	0.004
200	7.87	20	0.79	2	0.08	0.2	0.008
300	11.81	30	1.18	3	0.12	0.3	0.012
400	15.74	40	1.57	4	0.16	0.4	0.016
500	19.68	50	1.97	5	0.20	0.5	0.020
600	23.62	60	2.36	6	0.24	0.6	0.024
700	27.56	70	2.76	7	0.28	0.7	0.028
800	31.50	80	3.15	8	0.31	0.8	0.031
900	35.43	90	3.54	9	0.35	0.9	0.035

1 000 mm or 1 m = 39.37 in.

INCHES TO MILLIMETRES

Inches	mm	Inches	mm	Inches	mm	Inches	mm
1	25.4	0.1	2.54	.01	0.254	.001	0.025
2	50.8	0.2	5.08	.02	0.508	.002	0.050
3	76.2	0.3	7.62	.03	0.762	.003	0.076
4	101.6	0.4	10.16	.04	1.02	.004	0.102
5	127.0	0.5	12.70	.05	1.27	.005	0.127
6	152.4	0.6	15.24	.06	1.52	.006	0.152
7	177.8	0.7	17.78	.07	1.78	.007	0.178
8	203.2	0.8	20.32	.08	2.03	.008	0.203
9	228.6	0.9	22.86	.09	2.29	.009	0.229

10 in. = 254 mm; 12 in. or 1 ft. = 304.8 mm or 30.48 cm

METRIC TYPE SIZE

The present system of measuring type size by points and picas is difficult to use. New methods based on fractions of millimetres are being considered. No decision has been made. When a decision is made, it will take a long time to change to the new sizes because equipment now in use will be used for some time.

A metric type system was proposed by S. J. Heden of Stockholm, Sweden in December, 1969.

The Heden system* proposes a unit called "d" for measuring type size. One "d" is defined as 0.1 of millimetre. Unit "d" is used to specify type size, body size, line spacing and width of margins. With the Heden system, type size would be indicated by a two-number code. The first number gives the mainstroke size; the second number gives the body size. For example, the symbol 35/48 would mean: a mainstroke of 3.5 mm and a body size of 4.8 mm.

type size in "d"	type size in points
35/48	14
45/60	18
60/75	24
75/100	30
90/130	36

To find the body size in points, multiply the first number (mainstroke "d" size) by 4.

Using the Heden system, calculation of line widths and text lengths would be much simpler.

The British* have proposed a metric type size system very similar to the Heden method except that type height, character depth, and line spacing would be based on a unit of measurement of 0.025 mm. Twenty-two preferred type sizes were proposed, ranging from 1.75 mm to 9 mm.

*These two systems are described in greater detail in *Going Metric With The US Printing Industry*, pp. 90-94 (see References). Check with your professional organization for the current status of these proposed standards.

ANY WAY YOU WANT IT

1. You are working in a graphics company. With the change to metric measurement some of the things you order, sell or use are marked only in metric units. You will need to be familiar with appropriate Customary equivalents in order to communicate with customers and suppliers who use Customary units. To develop your skill use the Table on Information Sheet 10 and give the approximate metric quantity (both number and unit) for each of the following Customary quantities.

	Customary Quantity	Metric Quantity
a)	4 qts. of rubber cement	
b)	3/4 in. lithography tape	
c)	1 pt. of developer	
d)	one-gallon can	
e)	1 lb. of fixer crystal	
f)	2 fl. oz. of acrylic paint	
g)	8 fl. oz. of photo-type printer developer	
h)	1 in. Speedball steel brush	
i)	2 in. stick-on letters	
j)	12 in. sheet of Rubylith	
k)	3 yd. roll of charting tape	
l)	2 oz. of pliable plastic adhesive	
m)	2 in. wide image master	
n)	2 lbs. of pliable plastic adhesive	
o)	4 in. burnisher	
p)	6 oz. of dry chemical	

2. Use the conversion tables from Table 3 to convert the following:

a) 210 mm = ________________ in.
b) one-half inch letters = __________ mm letters
c) 16 in. x 24 in. = ______________ mm x ________ mm
d) 610 mm = ________________ in.

3. Complete the Requisition Form using the items listed. Convert the Customary quantities to metric before filling out the form. Complete all the information (Date, For, Job No., etc.). Order the following graphics supplies:

a) Four pts. of rubber cement
b) Two 3 fl. oz. jars of black drawing ink
c) One roll of litho tape 3/8 in. wide
d) 2 lbs. of adhesive wax
e) One pack of 2 in. paper type letters

REQUISITION

Date ____________

For ______________________________

____

Job No. ____________ Date Wanted ____________

Deliver to ______________________________

QTY	UNIT	ITEM

Requested by ______________________

Approved by ______________________

SECTION A

1. One kilogram is about the mass of a:

   [A] nickel

   [B] apple seed

   [C] basketball

   [D] Volkswagen "Beetle"

2. A square metre is about the area of:

   [A] this sheet of paper

   [B] a card table top

   [C] a bedspread

   [D] a postage stamp

3. The mass of a carton of rubber cement is measured in:

   [A] kilograms

   [B] cubic metres

   [C] millilitres

   [D] centimetres

4. Small quantities of liquids are measured in:

   [A] centimetres

   [B] kilograms

   [C] millilitres

   [C] cubic metres

5. The size (width) of a roll of film is measured in:

   [A] kilograms

   [B] millilitres

   [C] millimetres

   [D] kilometres

6. Type and line spacing is measured in:

   [A] centimetres

   [B] millilitres

   [C] milligrams

   [D] millimetres

7. The correct way to write twenty grams is:

   [A] 20 gms

   [B] 20 Gm.

   [C] 20 g.

   [D] 20 g

8. The correct way to write twelve thousand millimetres is:

   [A] 12,000 mm.

   [B] 12.000 mm

   [C] 12 000mm

   [D] 12 000 mm

SECTION B

9. A layout 60 centimetres wide also has a width of:

   [A] 6 000 millimetres

   [B] 0.6 millimetre

   [C] 6 millimetres

   [D] 600 millimetres

10. 750 millilitres of rubber cement is the same as:

    [A] .075 litre

    [B] 0.75 litre

    [C] 7.5 litres

    [D] 7 500 litres

SECTION C

11. For measuring millimetres you would use a:

    [A] ruler

    [B] scale

    [C] pressure gage

    [D] measuring cup

12. For measuring millilitres you would use a:

    [A] ruler

    [B] measuring cup

    [C] scale

    [D] pressure gage

13. For measuring kilograms you would use a:
    - [A] pressure gage
    - [B] thermometer
    - [C] ruler
    - [D] scale

14. For measuring Celsius you would use a:
    - [A] ruler
    - [B] thermometer
    - [C] scale
    - [D] pressure gage

15. Estimate the length of the line segment below:
    - [A] 23 grams
    - [B] 6 centimetres
    - [C] 40 millimetres
    - [D] 14 pascals

16. Estimate the length of the line segment below:
    - [A] 10 millimetres
    - [B] 4 centimetres
    - [C] 4 pascals
    - [D] 23 milligrams

SECTION D

17. The metric unit for mass which replaces the ounce is:
    - [A] milligram
    - [B] gram
    - [C] pascal
    - [C] millilitre

18. The metric unit for liquid measure which replaces the fluid ounce is:
    - [A] millilitre
    - [B] litre
    - [C] gram
    - [D] hectare

19. The metric unit for liquid measure which replaces the gallon is:
    - [A] kilogram
    - [B] gram
    - [C] kilolitre
    - [D] litre

Use this conversion table to answer questions 20 and 21.

mm	in.	mm	in.
100	3.94	10	0.39
200	7.87	20	0.79
300	11.81	30	1.18
400	15.74	40	1.57
500	19.68	50	1.97
600	23.62	60	2.36
700	27.56	70	2.76
800	31.50	80	3.15
900	35.43	90	3.54

20. The equivalent of 290 mm is:
    - [A] 11.41 in.
    - [B] 29.32 in.
    - [C] 12.00 in.
    - [D] 7.87 in.

21. The equivalent of 610 mm is:
    - [A] 24 in.
    - [B] 12 in.
    - [C] 8 1/2 in.
    - [D] 18 in.

ANSWERS TO EXERCISES AND TEST

EXERCISES 1 THRU 6

The answers depend on the items used for the activities.

EXERCISE 7

Currently accepted metric units of measurement for each question are shown in Table 2. Standards in each occupation are being established now, so answers may vary.

EXERCISE 8

a)	2.6 cm	e)	13.2 cm
b)	58.3 cm	f)	80.2 cm
c)	9.4 cm	g)	140.0 cm
d)	68.0 cm	h)	230.7 cm

EXERCISES 9 THRU 13

Tables are reproduced in total. Answers are in parentheses.

Exercise 9

metre m	centimetre cm	millimetre mm
1	100	1 000
2	200	(2 000)
3	(300)	(3 000)
9	(900)	(9 000)
(5)	(500)	5 000
74	(7 400)	(74 000)
0.8	80	(800)
0.6	(60)	600
(0.025)	2.5	25
(0.148)	(14.8)	148
(6.39)	639	(6 390)

Exercise 10

millilitres ml	litres l
3 000	3
6 000	(6)
(8 000)	8
(14 000)	(14)
(23 000)	23
300	0.3
700	(0.7)
(900)	0.9
250	(0.25)
(470)	0.47
275	(0.275)

Exercise 11

litres l	millilitres ml
8	8 000
5	(5 000)
46	(46 000)
(32)	32 000
0.4	(400)
0.53	(530)
(0.48)	480

Exercise 12

grams g	kilograms kg
4 000	4
9 000	(9)
23 000	(23)
(8 000)	8
300	(0.3)
275	(0.275)

Exercise 13

kilograms kg	grams g
7	7 000
11	(11 000)
(25)	25 000
0.4	(400)
0.63	(630)
(0.175)	175

Exercise 14

a)	5 m	j)	1 000 cm
b)	0.25 litre	k)	5 000 cm
c)	300 mm	l)	30 cm
d)	2.5 kg	m)	50 mm
e)	12 cm	n)	5 mm
f)	250 ml	o)	90 cm
g)	20 mm	p)	240 mm
h)	25 mm	q)	0.5 kg
i)	500 ml	r)	1 t

EXERCISES 15 AND 16

The answers depend on the items used for the activities.

EXERCISE 17

Part 1.

a)	3.8 litres	i)	5.08 cm
b)	1.905 cm	j)	30.48 cm
c)	0.47 litre	k)	2.73 m
d)	3.79 litres	l)	56.6 g
e)	0.45 kg	m)	5.08 cm
f)	59.2 ml	n)	0.90 kg
g)	236.8 ml	o)	10.16 cm
h)	2.54 cm	p)	169.8 g

Part 2.

a) 8.26 in.
b) 12.70 mm
c) 406.4 mm x 609.6 mm
d) 24.01 in.

Part 3.

a) 1.88 litres
b) 2 - 88.8 ml
c) 0.953 cm
d) 0.90 kg
e) 5.08 cm

TESTING METRIC ABILITIES

1.	C	8.	D	15.	B
2.	B	9.	D	16.	A
3.	A	10.	B	17.	B
4.	C	11.	A	18.	A
5.	C	12.	B	19.	D
6.	A	13.	D	20.	A
7.	D	14.	B	21.	A

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SUGGESTED METRIC TOOLS AND DEVICES NEEDED TO COMPLETE MEASUREMENT TASKS IN EXERCISES 1 THROUGH 5

(* Optional)

LINEAR

- Metre Sticks
- Rules, 30 cm
- Measuring Tapes, 150 cm
- *Height Measure
- *Metre Tape, 10 m
- *Trundle Wheel
- *Area Measuring Grid

VOLUME/CAPACITY

- *Nesting Measures, set of 5, 50 ml - 1 000 ml
- Economy Beaker, set of 6, 50 ml - 1 000 ml
- Metric Spoon, set of 5, 1 ml - 25 ml
- Dry Measure, set of 3, 50, 125, 250 ml
- Plastic Litre Box
- Centimetre Cubes

MASS

- Bathroom Scale
- *Kilogram Scale
- *Platform Spring Scale
  - 5 kg Capacity
  - 10 kg Capacity
- Balance Scale with 8-piece mass set
- *Spring Scale, 6 kg Capacity

TEMPERATURE

- Celsius Thermometer

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SUGGESTED METRIC TOOLS AND DEVICES NEEDED TO COMPLETE OCCUPATIONAL MEASUREMENT TASKS

In this occupation the tools needed to complete Exercises 6, 15, and 16 are indicated by "★."

A. Assorted Metric Hardware—Hex nuts, washers, screws, cotter pins, etc.
B. Drill Bits—Individual bits or sets, 1 mm to 13 mm range
C. Vernier Caliper—Pocket slide type, 120 mm range
D. Micrometer—Outside micrometer caliper, 0 mm to 25 mm range
E. Feeler Gage—13 blades, 0.05 mm to 1 mm range
F. Metre Tape—50 or 100 m tape
G. Thermometers—Special purpose types such as a clinical thermometer
★ H. [1] Temperature Devices—Indicators used for ovens, freezing/cooling systems, etc.
I. Tools—Metric open end or box wrench sets, socket sets, hex key sets
J. Weather Devices—Rain gage, barometer, humidity, wind velocity indicators
K. [1] Pressure Gages—Tire pressure, air, oxygen, hydraulic, fuel, etc.
L. [1] Velocity—Direct reading or vane type meter
M. Road Map—State and city road maps
★ N. Containers—Buckets, plastic containers, etc., for mixing and storing liquids
O. Containers—Boxes, buckets, cans, etc., for mixing and storing dry ingredients

Most of the above items may be obtained from local industrial, hardware, and school suppliers. Also, check with your school district's math and science departments and/or local industries for loan of their metric measurement devices.

[1] Measuring devices currently are not available. Substitute devices (i.e., thermometer) may be used to complete the measurement task.

REFERENCES

Let's Measure Metric. A Teacher's Introduction to Metric Measurement. Division of Educational Redesign and Renewal, Ohio Department of Education, 65 S. Front Street, Columbus, OH 43215, 1975, 80 pages; $1.50, must include check to state treasurer.

Activity-oriented introduction to the metric system designed for independent or group inservice education study. Introductory information about metric measurement; reproducible exercises apply metric concepts to common measurement situations; laboratory activities for individuals or groups. Templates for making metre tape, litre box, square centimetre grid.

Going Metric with The U.S. Printing Industry. Clive A. Cameron, Graphic Arts Research Center, Rochester Institute of Technology, Rochester, NY 14623, 1972, 175 pages, $8.70, paper.

Book on metric conversion for printing and graphics industry. Chapters on evolution of measurement; commentary on conversions in Britain and Japan; metric systems applications in paper and packaging, typesetting, and machinery and equipment; also has findings of a survey on attitudes of graphic arts firms toward the metric standard. Has related tables and graphics.

Measuring with Meters, or, How to Weigh a Gold Brick with a Meter-Stick. Metrication Institute of America, P.O. Box 236, Northfield, IL 60093, 1974, 23 min., 16 mm, sound, color; $310.00 purchase, $31.00 rental.

Film presents units for length, area, volume and mass, relating each unit to many common objects. Screen overprints show correct use of metric symbols and ease of metric calculations. Relationships among metric measures of length, area, volume, and mass are illustrated in interesting and unforgettable ways.

Metric Education, An Annotated Bibliography for Vocational, Technical and Adult Education. Product Utilization, The Center for Vocational Education, The Ohio State University, Columbus, OH 43210, 1974, 149 pages; $10.00.

Comprehensive bibliography of instructional materials, reference materials and resource list for secondary, post-secondary, teacher education, and adult basic education. Instructional materials indexed by 15 occupational clusters, types of materials, and educational level.

Metric Education, A Position Paper for Vocational, Technical and Adult Education. Product Utilization, The Center for Vocational Education, The Ohio State University, Columbus, OH 43210, 1975, 46 pages; $3.00.

Paper for teachers, curriculum developers, and administrators in vocational, technical and adult education. Covers issues in metric education, the metric system, the impact of metrication on vocational and technical education, implications of metric instruction for adult basic education, and curriculum and instructional strategies.

Metrics in Career Education. Lindbeck, John R., Charles A. Bennett Company, Inc., 809 W. Detweiller Drive, Peoria, IL 61614, 1975, 103 pages, $3.60, paper; $2.70 quantity school purchase.

Presents metric units and notation in a well-illustrated manner. Individual chapters on metrics in drafting, metalworking, woodworking, power and energy, graphic arts, and home economics. Chapters followed by several learning activities for student use. Appendix includes conversion tables and charts.

Taking the Tricks Out of Metrics. Metric Training Department, Creative Universal, Inc., Tower 14, 21700 Northwestern Highway, Southfield, MI 48975, 1976, 4 booklets; $3.00 each, $12.00 set, discounts.

Series of booklets presents step-by-step directions, questions, answers on how to read metric measurement tools: micrometers, vernies calipers, rules, dial indicators.

METRIC SUPPLIERS

Brown & Sharpe Manufacturing Co., Precision Park, North Kingstown, RI 02852

Industrial quality micrometers, steel rules, screw pitch and thickness gages, squares, depth gages, calipers, dial indicators, conversion charts and guides.

Central Instrument Company, 900 Riverside Drive, New York, NY 10032.

Drafting rules and scales for drafting, engineering, architecture, conversion tables and slides, posters, teaching aids, drafting templates.

Dick Blick Company, P.O. Box 1267, Galesburg, IL 61401

Instructional quality rules, tapes, metre sticks, cubes, height measures, trundle wheels, measuring cups and spoons, personal scales, gram/kilogram scales, feeler and depth gages, beakers, thermometers, kits and other aids.

The L. S. Starrett Company, 121 Crecent Street, Athol, MA 01331.

Machine tool precision measuring devices, micrometers, calipers, dial indicators, steel rules.

Ohaus Scale Corporation, 29 Hanover Road, Florham Park, NJ 07932

Instructional quality and precision balances and scales, plastic calipers and stackable gram cubes for beginners.

INFORMATION SOURCES

American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D C 20036

Charts, posters, reports and pamphlets, *Metric Reporter* newsletter. National metric coordinating council representing industry, government, education, professional and trade organizations.

Metric Committee, National Association of Photographic Manufacturers, 600 Mamaroneck Avenue, Harrison, NY 10528.

Trade association which is establishing product standards, recommending practices for the use of measurement units, and coordinating metric changeover in the industry.

National Bureau of Standards, Office of Information Activities, U.S. Department of Commerce, Washington, D C 20234.

Free and inexpensive metric charts and publications, also lends films and displays.